ANNUAL PROJECT SUMMARY
Project period January 1, 2005 – December 31, 2005

TITLE: THE QUATERNARY GEOLOGIC FRAMEWORK FOR THE CITY OF SEATTLE AND THE SEATTLE-TACOMA URBAN CORRIDOR

Cooperative Agreement Number: 01HQAG0017

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NEHRP Element: I, Pacific Northwest region
Keywords: Geologic Mapping, Surficial Deposits, Tectonic Structures, Urban Geology

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INVESTIGATIONS UNDERTAKEN

Overview

Our investigations during this project year represent both continuation of and greater focus on specific elements of the Quaternary geologic framework of the Seattle area. Major accomplishments this year included multiple 7.5-minute geologic maps into or through USGS technical review, detailed new surficial mapping across portions of the Seattle and South Widbey Island fault zones, continued population of our subsurface geologic database, and dissemination of data and results through publication of maps and reports, and free public Internet access of our entire geologic database, currently numbering almost 70,000 exploration sites. Our emphasis on Quaternary geologic data is critical for any geologic or seismic-hazard study because most of the central Puget Lowland has a recent sedimentary cover one hundred to over one thousand meters thick.

During this project year, we accomplished the following tasks:

— Publication of two USGS SIM-series 7.5-minute quadrangle maps (Olalla, SIM-2902, and Seattle NW, SIM-2903) and one open-file series map (City of Seattle, OF-2005-1252);

— Completion (or anticipated completion, by 12/31/05) of USGS technical review for SIM-series 7.5-minute quadrangle maps of Seattle SE and SW, Tacoma North, Tacoma South, Puyallup, Gig Harbor, and Steilacoom;

— Continued population of a database of existing subsurface geologic and geotechnical data, with an additional 4,000 individual records (points) of subsurface geologic information (now 69,100 total);

— Response to ongoing requests for information from USGS scientists within and outside of the Earthquake Program, other Federal agencies, local governments, private consultants, and the public; and

—Over five-fold leveraging of USGS NEHRP funds for 2005 that has expanded both the data collection and the geographic scope of the project.

Background

Our investigations during this seventh year of the project represent the continuation and development of a wide range of tasks that focus on the Quaternary framework of the Seattle area. We originally defined five major components to develop this framework and to disseminate the resulting information:

1. Develop the regional stratigraphy and chronology for the central Puget Lowland;
2. Create a subsurface geologic database for the City;
3. Prepare new surficial geologic maps of the City;
4. Develop the geologic model (3-D map and database) of the City; and
5. Provide education and technical outreach.

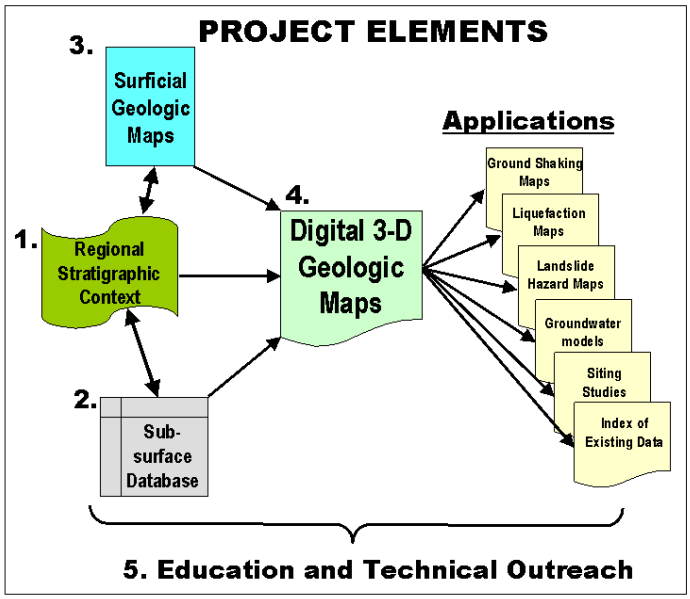

Figure 1: Elements of the Seattle Geologic Mapping Project

The overall progress of this effort has been summarized in previous Annual Reports, of which the most recent can be accessed at *http://erp-web.er.usgs.gov/reports/annsum/vol46/pn/01hqag0017.pdf*.

Our focus this year has been on understanding and mapping the Quaternary deposits in areas adjacent to and northeast of Lake Washington, in support of current research efforts to locate and characterize the Seattle and Southern Whidbey Island fault zones. These deposits are primary determinants of the magnitude and location of strong ground shaking, and so knowledge of the thickness, geometry, and density variations of these deposits is critical to the ongoing seismic evaluations across this region. Our studies provide both the raw data and the geologic interpretations to characterize the material properties and topography of Quaternary and bedrock materials. We are actively developing a detailed understanding and representation of the three-dimensional distribution of geologic materials beneath Seattle and surrounding urban areas and embedding that information in the context of a coherent, regionally integrated geologic framework for the central Puget Sound region. This work, which includes detailed geologic mapping and database development, is already supporting both seismic research and a host of

other earthquake-related investigations, including liquefaction, landsliding, and lateral-spreading analyses.

RESULTS

Subsurface Geologic Database

We have developed, and are continuing to populate, a database of existing subsurface geologic and geotechnical data that covers broad areas of the Puget Lowland (Figure 2). This database accommodates both spatial and nonspatial data by following a GIS-based approach. The design facilitates spatial analyses, visualization, and other representations of the data.

Since the project's inception, the land area covered by the database has expanded significantly from its original Seattle-only coverage. This has been a direct consequence of additional funding obtained from both NEHRP and local agencies. Our progress to date in populating the main tables of the database is as follows:

	Total study area (as of 11/05)	City of Seattle only
Geotechnical Documents	13,978	6,381
Exploration Points	69,068	31,891
Subsurface Layers	286,713	133,662

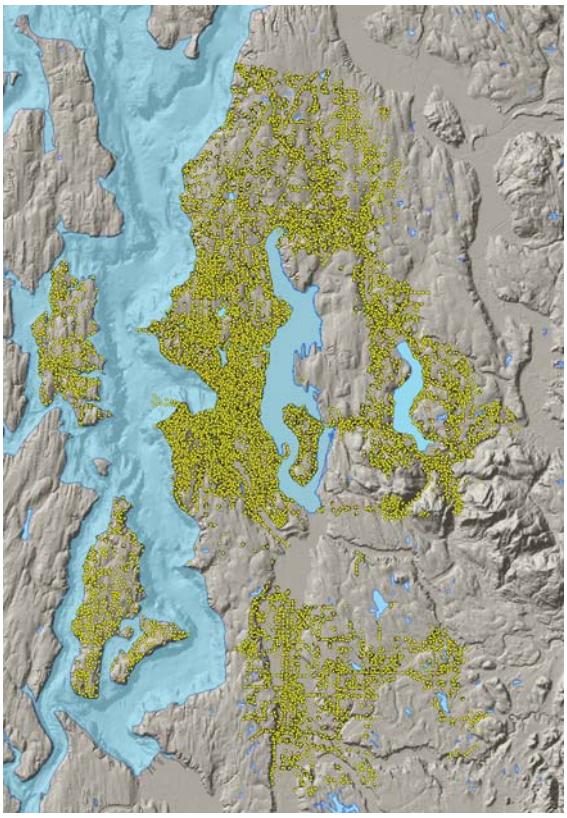

Figure 2. Current areas of coverage for the subsurface geologic database.

Geologic Mapping

In the past year, we have published two USGS SIM-series 7.5-minute maps (Olalla, SIM-2902, and Seattle NW, SIM-2903) and one open-file series map (City of Seattle, OF-2005-1252 and have completed (or anticipate completion by 12/31/05) USGS technical reviews for SIM-series 7.5-minute maps of Seattle SE and SW, Tacoma North, Tacoma South, Puyallup, Gig Harbor, and Steilacoom. With this year's NEHRP funding, we have focused new mapping on the Mercer Island quadrangle, shown in Figure 3a; and an area encompassing eastern Bothell, southwestern Maltby, and the northern Redmond quadrangles, shown in Figure 3b. This year's proposal funded about one-quarter of the work to complete the Mercer Island quadrangle; of the remaining amount, more than half has been provided by the City of Mercer Island and we anticipate that the City of Bellevue will be contributing most or all of the balance over the next year or two.

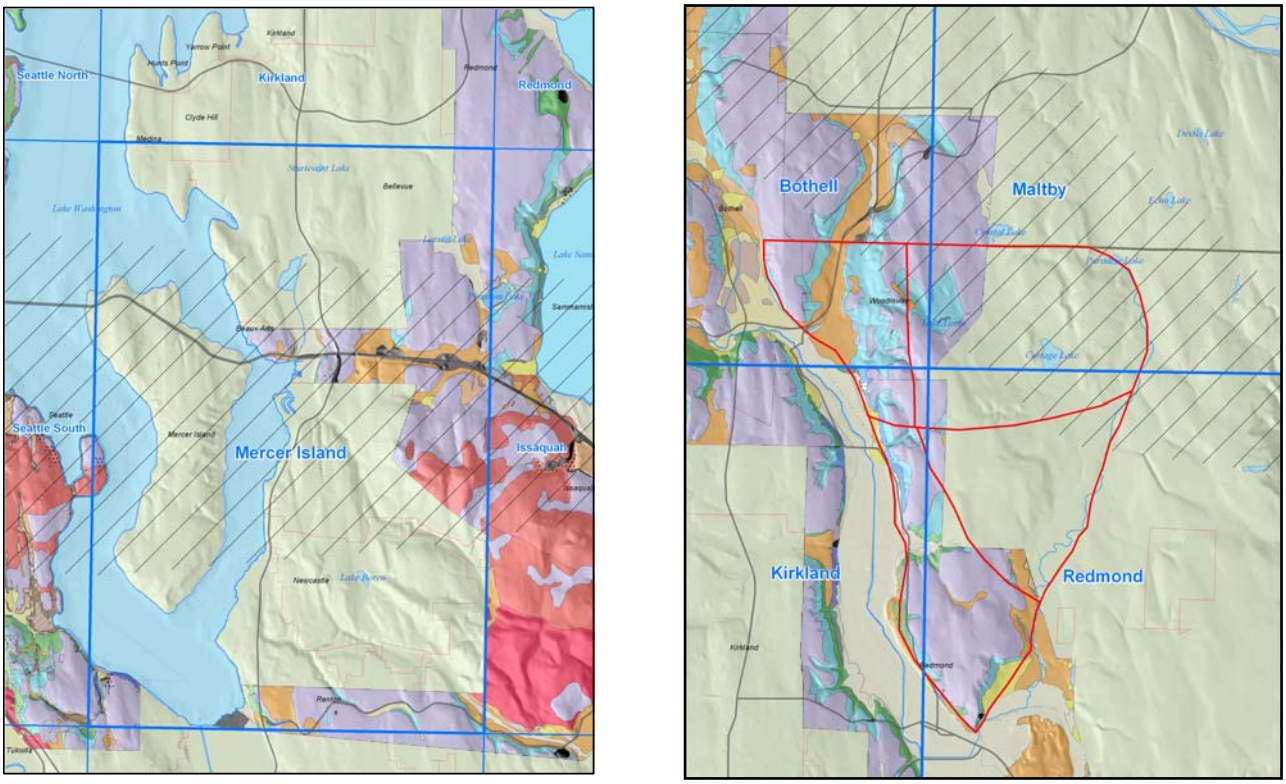

Figure 3. Mapping in the Mercer Island quadrangle (3a, left) and Redmond/Maltby area (3b, right). Current approximations of fault zone locations shown by red hatchures.

In previous years we developed a partnership with the Water and Land Resources Division of King County to expand our geologic database and mapping efforts, and to populate our database with groundwater information. This year, that effort was directed in part to portions of Woodinville and Redmond, which overlaps with the area of the South Whidbey Island fault zone that is also a focus for this year's NEHRP effort. By coordinating this work with the USGS, we have completed geologic mapping for the SW 1/8 of the Maltby quadrangle and the

NW 1/4 of the Redmond quadrangle. Additional data collection adjacent to this area is continuing with a modest, but likely ongoing, agreement with King County Department of Development and Environmental Services.

Publication and Outreach

Borehole metadata, subsurface layer data, geologic maps, and recent publications can be accessed through our website (http://geomapnw.ess.washington.edu). In addition, as geologic maps reach final draft stage, they are posted on our website. As of the end of 2005, 15 maps were available online: the Seattle NW, NE, and SW geologic maps at 1:12,000 scale; the composite geologic map of Seattle at 1:24,000 scale; the Issaquah, Olalla, Gig Harbor, Des Moines, Poverty Bay, Tacoma North, Tacoma South, Steilacoom, and Puyallup quadrangles (1:24,000); northwestern King County and southwestern Snohomish County (1:24,000); and the geologic map of King County (1:100,000).

We are in the process of scanning all of our borehole data, and making the scanned images available on the web as pdf files. Currently about 60% of our files are scanned and available. The public can also view our originals and make copies of our borehole documents. Many consultants and other interested parties have taken full advantage of this resource both online and in person.

NON-TECHNICAL SUMMARY
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NEHRP Element: I, Pacific Northwest region
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Many engineering applications in urban areas are impacted by the spatial distribution of geologic materials. This project is developing a detailed understanding and representation of the three-dimensional distribution of geologic materials beneath Seattle and the surrounding region, with a focus on the major earthquake-generating structures of the central Puget Lowland. To date, we have acquired and organized almost 70,000 items of geologic information, representing a substantial fraction of the vast amount of existing data; in combination with our ongoing field investigations, we are preparing and publishing the geologic maps to display this information for scientists, agencies, and the public.

REPORTS PUBLISHED

2005

Manuscripts:

Booth, D.B., Troost, K.G., S.A. Shimel, M.A. O'Neal, and A. P. Wisher, in press, New Geologic mapping and geologic database for the urbanized Puget Lowland, western Washington State, USA: Proceedings, AASG/USGS 2005 Workshop on Digital Mapping Techniques.

Abstracts:

Troost, K. G., Booth, Derek B., Shimel, S., Wisher, A, and O'Neal, M., 2005, Detailed geologic mapping—is it worth the cost? Applications of a geodatabase of the Seattle, Washington area: Geological Society of America, Abstracts with Programs, Annual Meeting, v. 37.

Troost, K. G., Johnson, K. H., Booth, Derek B., Ogier, S., and Wisher, A, 2005, Aquifer susceptibility mapping of Vashon-Maury Island, King County, Washington: Abstract volume, 5th Symposium on the Hydrogeology of Washington State, Tacoma, Washington, April 12-14, 2005, p. 113.

Troost, K. G., Booth, Derek B., Shimel, S., Wisher, A, and O'Neal, M., 2005, Is new, detailed 1:12,000-scale geologic mapping worth the cost? Hydrogeologic applications of a geologic database of the Seattle area, Washington: Abstract volume, 5th Symposium on the Hydrogeology of Washington State, Tacoma, Washington, April 12-14, 2005, p. 114.

GEOLOGIC MAPS—current status (12/05):

In preparation

Troost, K.G., Wisher, A.P., Booth, D.B., and Shimel, S.A., in prep., Geologic map of the Mercer Island quadrangle: U.S. Geological Survey SIM series, scale 1:24,000.

Troost, K.G., Wisher, A.P., Booth, D.B., and Shimel, S.A., in prep, Geologic map of the Kent and Auburn Areas: U.S. Geological Survey Open-File Report, scale 1:24,000.

In review

Booth, D.B., Troost, K.G., and Shimel, S.A., in review, Geologic map of the Seattle NE quadrangle: U.S. Geological Survey Scientific Investigations Map, scale 1:12,000.

Booth, D.B., Walsh, T.J., and Troost, K.G., in review, Geologic map of the Issaquah quadrangle: U.S. Geological Survey Scientific Investigations Map, scale 1:24,000.

Booth, D.B., Haugerud, R.A., and Sacket, J., in review, Geologic map of King County, Washington: U.S. Geological Survey Open-File Report, scale 1:100,000.

In press

Troost, K.G., in press, Geologic map of the Puyallup 7.5-minute quadrangle, Washington: U.S. Geological Survey Scientific Investigations Map, scale 1:24,000.

Troost, K.G., in press, Geologic map of the Tacoma South 7.5-minute quadrangle, Washington: U.S. Geological Survey Scientific Investigations Map, scale 1:24,000.

Troost, K.G. and Booth, D.B., in press, Geologic map of the Steilacoom 7.5-minute quadrangle, Washington: U.S. Geological Survey Scientific Investigations Map, scale 1:24,000.

Troost, K.G., Booth, D.B., and Borden, R.K., in press, Geologic map of the Tacoma North 7.5-minute quadrangle, Washington: U.S. Geological Survey Scientific Investigations Map, scale 1:24,000.

Troost, K.G., D.B. Booth, S.A. Shimel, R.J. Blakely, and R.E. Wells, in press, Geologic map of the Seattle SW quadrangle: U.S. Geological Survey Scientific Investigation Map, scale 1:12,000.

Troost, K.G., Booth, D.B., and Wells, R.E., in press, Geologic map of the Gig Harbor 7.5-minute quadrangle, Washington: U.S. Geological Survey Scientific Investigations Map, scale 1:24,000.

Troost, K.G., Booth, D.B., Wisher, A.P., and Shimel, S.A., in press, Geologic map of the Seattle SE quadrangle: U.S. Geological Survey Scientific Investigations Map, scale 1:12,000.

Published

Booth, D.B., and Troost, K.G., 2005, Geologic map of the Olalla 7.5-minute quadrangle, Washington: U.S. Geological Survey Scientific Investigations Map 2903, scale 1:24,000.

Booth, D.B., Troost, K.G., and Shimel, S.A., 2005, Geologic map of the Seattle NW quadrangle: U.S. Geological Survey Scientific Investigations Map 2902, scale 1:12,000.

Troost, K.G., Booth, D.B., Wisher, A.P., and Shimel, S.A., 2005, The geologic map of Seattle: U.S. Geological Survey Open-File Report 2005-1252, scale 1:24,000.

FINANCIAL NOTE

This project has been quite successful in leveraging the contribution of the USGS NEHRP funds through additional financial and in-kind support from other programs of the USGS and from local governments. Some of that support has been used to cover the initial shortfall of funds for the originally scoped NEHRP project (namely, the geologic map of the City of Seattle), some has been used to develop the scientific framework for Quaternary geologic investigations in the region (Component 1 of this project), and some has been used to expand the geographic scope of the effort into populated areas to the north, south, and east. Funding amounts are tabulated and also shown graphically below:

Project Funding 2000-2005:

SOURCE	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
USGS: NEHRP	$160,000	$170,000	$170,000	$125,000	$100,000	$75,000
USGS: NCGMP	$38,332	$12,450	$31,617	$36,975	$37,425	$25,000
City of Seattle: DCLU	$60,000	$60,000	$60,000	$60,000	$40,000	$30,000
City of Seattle: SPU	$50,000	$25,000	$25,000	$25,000	$25,000	$25,000
King Co. Groundwater			$25,000		$75,000	$82,000
Mercer Island					$50,000	$102,304
City of Bellevue						$50,000
WSDOT						$21,000
King Co. DDES						$20,000
Univ. of WA: CWWS	$20,000	$10,000	$10,000	$10,000	$10,000	
King Co. Wastewater		$327,449	$216,600	$278,420	$100,000	
Seattle Monorail				$20,000	$40,000	
Bainbridge Island					$75,444	
City of Bothell			$15,000			
	$328,332	**$604,899**	**$538,217**	**$555,395**	**$552,869**	**$430,304**